Polymer forming process

1. Pressureless processing
2. Processing under pressure

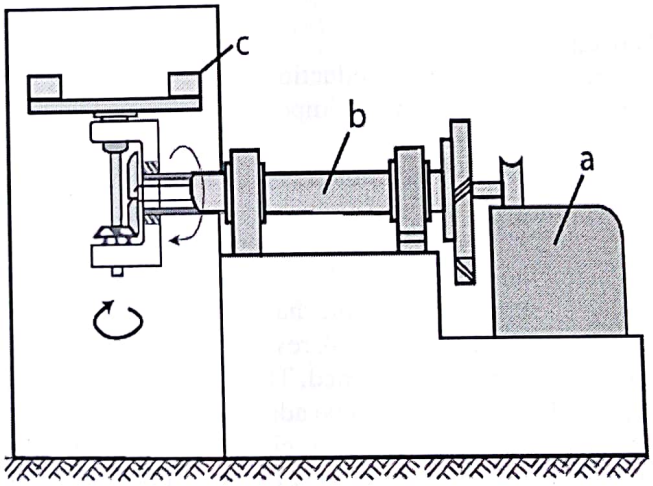
1. Pressureless processing

The Pressureless Processing Techniques are used for starting materials such as monomers, plastic solutions and dispersions that can flow and that can be formed without application of external forces. The pressureless processing techniques include –

1. Casting
2. Dipping
3. Coating
4. Foaming

1 .Casting:

By polymerizing monomers in molds, thick –walled articles, embeddings, sheets and blocks can be produced. These are preferentially made up of polystyrene, polyamides and polymethylmetacrylate. Inorder to avoid thermal stresses, adequate temperature regulation is required. The mold material choice is dependent upon the use and surface quality of the moldings. Film casting is mainly used in the photographic industry for the manufacture of cellulose acetate films. In this method of casting, polymer solution, melts or dispersions are cast directly into a metal drum or a rotating belt ; and from a slot die into precipitation bath.



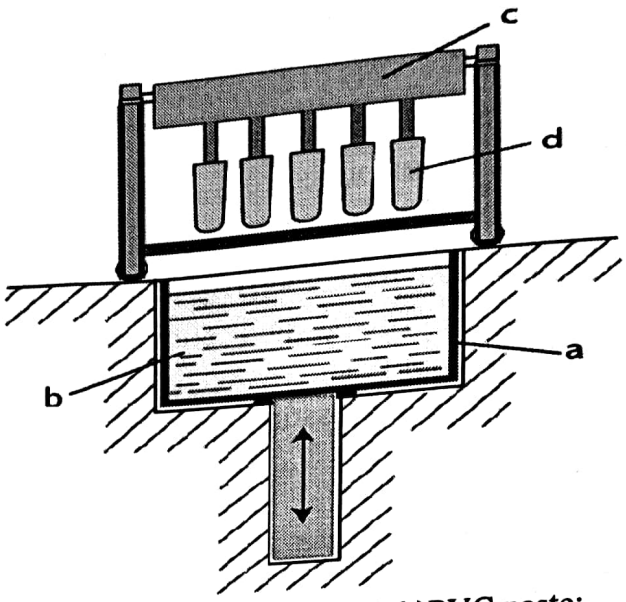
Casting Machine a) Motor ; b)Drive Shaft; c)Molds

Slush molding enables the production of hollow articles which are made from PVC pastes. These are made using two part metal molds, which are heated and filled with the paste. The paste gels on the outermost edges forming a skin ; and subsequently the excess paste is poured off. The remaining layer is gelled in an oven and after cooling, a hollow mold is obtained. Slush molding can be further modified into Rotational casting for the production of hollow articles, made from PVC. The only difference is that in rotational casting, the amount of PVC paste is metered to the mold, which makes the removal of excess paste and post gelation techniques redundant. The mold is rotated about two perpendicular axes, while heating, and this enables uniform wetting of the cavity surface. Roatational casting has the advantage of low investment cost over slush, molding. In the manufacture of thick-walled , symmetrical structures such as pipes and sockets, centrifugal casting may be used. A partially filled mold is rotated rapidly about an central axis. Centrifugal force press the material outward in the mold, and in the process, the material gets compacted.

2 .Dipping :

Sometimes, molds or articles are dipped into solutions , dispersions, pastes, melts or powders. Later on, the adhering material on the surface is solidified by heat treatment.

For manufacturing articles such as gloves, boots etc. in which one side remains open , appositivemold is immersed and subsequently the casting is gelled. A series of identical molds mounted on dipping frames are used for the mass production of such articles. During the dipping process, degassed PVC paste placed in a vessel is raised and lowered. Sometimes, the dipping frame is moved, while the vessel is stationary. The immersion and removal stages are carried out slowly to allow the material to flow homogeneously from the mold and to prevent the introduction of air into the paste. The gelation is usually carried out in circulating air oven, and during the process the paste temporarily becomes fluid. The molds containing the gelled coating are immers around 50 C and at this temperature, the moldings can be easily removed from the molds. Cables and wires are extensively coated using this process.

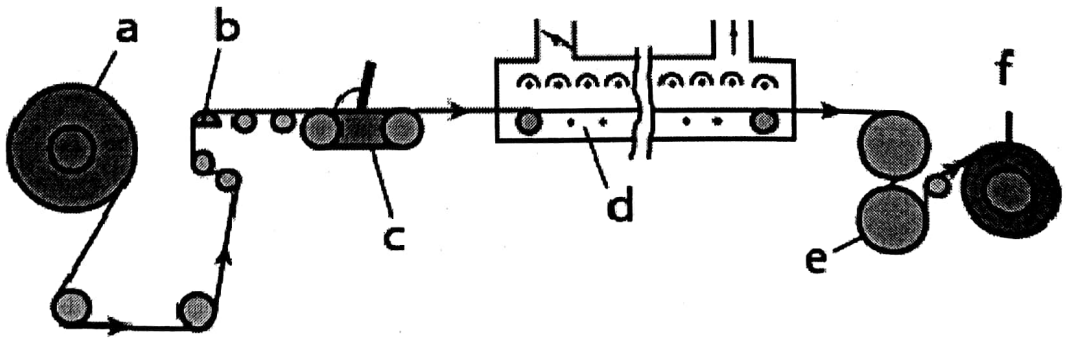


Dipping Unit. a)Vessel; b)PVC paste; c)Dipping frame; d)Molds

3 . Coating:

This process is used in the production of self-supporting films by coating sheet materials such as paper and textiles. The most important materials that are used forthe production of coatings are PVC pastes.

The equipment for coating consists of an unwinding station, an expander, coating head, gelling channel, cooling system, and a rewind station. The disk brakes slows down the unwind station, and the rewind station enables the product to be held under tension. A smooth finish to the sheet is provided by the expanders. With the help of the coating head, the PVC paste is spread upon the moving sheet manually or mechanically. Thereafter, a doctor blade is employed to spread the sheet to required thickness. A revolving roller supports the sheet, due to which an exactly defined contact area is maintained. The rolls distribute the escaping paste and form a film. The rotation speeds of the rolls can be adjusted. Hot air or infrared dryers supply the heat required for gelation of the paste. However, circulating air heating in combination with infrared heaters is used in some cases. The cooling effect must be high enough so that no adhesion between the individual layers occurs. The cooling is attained by two water – cooled , corrosion – resistant hollow drums.



Coating unit **a) Unwinding Station; b) Expander; c)Coating head; d)Gelling Tunnel; e)Cooling Roll; f)Rewind Station**

4 . Foaming

By adding physical or chemical blowing agents to a polymer, foams are generated. Physical blowing agents include gases and low-boiling compounds , whereas ; chemical blowing agents generally are gas – releasing compounds. Only a few materials are employed in the manufacture of foams , such as polystyrene , PVC, LDPE as well as phenolic and polyurethane resins. The foaming process must begin when the polymer is in a flowable form and allows bubbles to develop. The conditions are fixed, once the bubbles reach the optimum size.

2. Polymer Processing under pressure

Sometimes the molding process is carried under high pressure in which the solid thermoplastic materials are melted, molded and cooled subsequently. Some of the commonly used techniques for processing under pressure are –

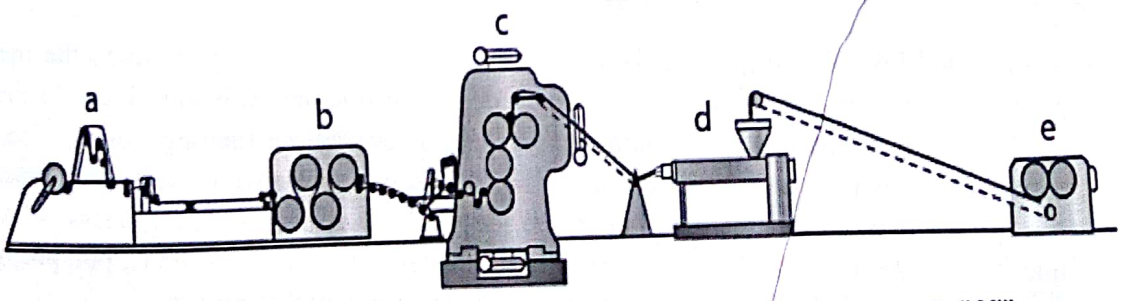
1. Compression molding
2. Rolling and Calendering
3. Extrusion
4. Blow Molding
5. Injection Molding

1. Compression Molding:

For the manufacture of thick – walled components and those that cannot be plasticized in extruders, compression molding is used. It plays an important role in the processing of elastomers and thermosets. A press consisting of fixed and moving platens is used. The plunger and cavity components are mounted on these plates, and the parting plane is kept horizontal. The cavity is filled with the cold plastic and is melted by heating the mold under low pressure. When the melting is complete, the mold is closed and pressure applied. The molding is removed by releasing the press once the ejection temperature is reached. Compression molding is uneconomical due to the fact that the process has a long cycle time ; as the material in themold is heated and cooled by conduction via the mold surface.

2. Rolling and Calendering:

The rolling mills consist of two rolls that are used exclusively for the compounding of thermoplastics. The product that results from rolling is a sheet that can be granulated after cooling or fed in plasticated form directly into the processing equipment. PVC and rubber are processed using this process. When the rolls are more than to in number, and the polymer is to be shaped using these rolls; then the machine is called a calendar. The number of rolls in a calendar can be uptoseven ; however, most commonly , four rolls are used. The rolls are made of polished cast iron, and are driven individually and heated. The heating medium is usually oil or water. The temperature and speed increases from one roll to the next. The roll mill must be able to withstand the extreme forces to which it is exposed, and hence, be made extremely rigid. Thecalenders are one of the most expensive types of processing equipments and are employed for the manufacture of a few special products like floor coverings and films made of plasticised PVC.

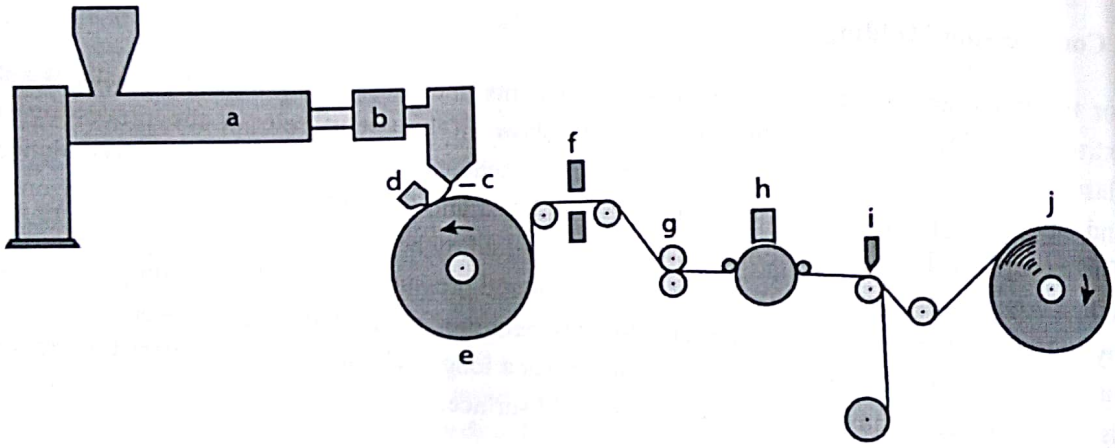


Calendering line a) Winder and Edge Cutter; b)Cooling Rolls; c)Four-roll calendar; d)Extruder; e)Mixing Roll Mill.

3. Extrusion:

This method enables the attainment of awide range of film thickness, and large scaling processing. Moreover, there is no necessity for expensive solvents in the recovery systems. A device known as extruder is used to melt the polymer, which is given the specific shape by a die. Later on, a cooling system is used to solidify it. At the onset , the raw material is dried using heated air or vacuum, before it is melted in the extruder. The extruders may be single – screw extruders, or twin screw extruders, the single screw extruder being the most common. The melt is filtered depending upon the desired purity, and then the filtered raw materials are sent through the slot die. The width and thickness of the film are determined by the width of the die and the die gap respectively. The die gap can be further adjusted during production. The melt film emerging from the die is cast on to a highly polished roll. A vacuum device prevents the entrapment of air between the melt and the roller surface. The final film that is obtained is wound onto a roll after trimming off the edges. In a separate process, the film is cut into the designate width.

Extrusion Molding a) Extruder; b) Filter; c)Slot Die; d)Air Knife; e)Cooling Roll; f) Device for measuring film thickness;



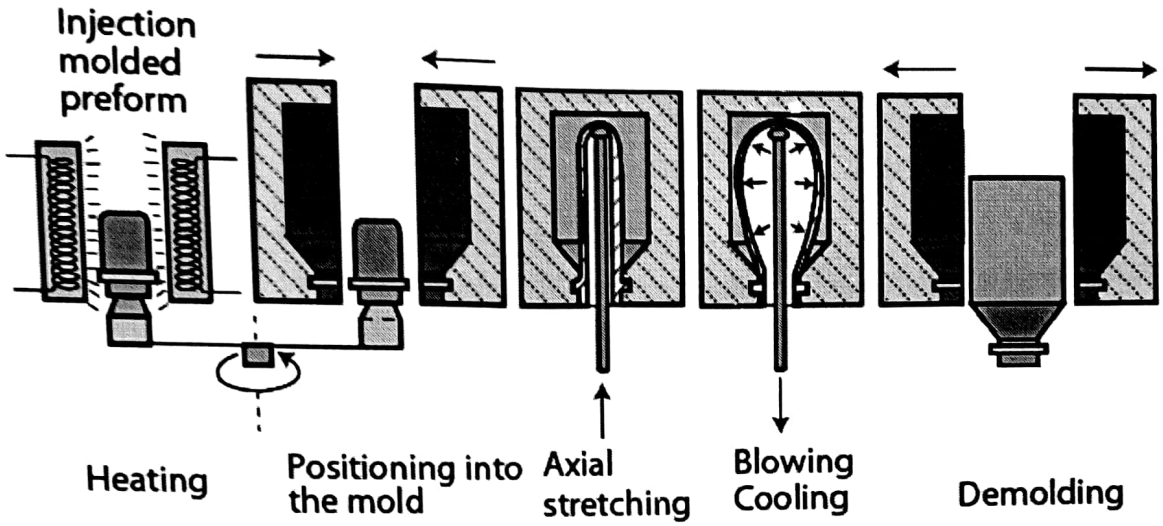
g)Tension rolls; h) Corona Treatment; i)Edge Treatment; j) Winding

4. BlowMolding :

This is the most common method for manufacturing hollow articles from thermoplastics . The most simple products and articles that are made by blow molding are bottles, ventilation ducts, suit cases and fuel tanks for automobiles. Two processes are generally followed for blow molding –

a .Extrusion Blow Molding : An extruded tube or parison is elongated to reach the required length . Theparison is then enclosed by themold , which is then cut by a blade. It is then conveyed to the blowing station. In the blowing station, a blow mandrel is inserted into the mold and the actual process is subsequently carried out. It is then cooled and the finished product is removed by opening the mold. The open mold is then transferred to theposition below the extrusion die inorder to receive a new parison. The process then continues.

b .Stretch Blow Molding : This is a special form of blow molding in which the mechanical properties are considerably improved. A high degree of orientation is introduced in the plastics by drawing near the glass transition temperature or crystalline melting points. The molding material is drawn not only in the circumferential direction, but also in the machine direction. A mechanical ram is used for drawing in the longitudinal direction. The process is carried out under low temperature with the application of high deformation forces. PVC, polypropylene and poly ethyl terephthalate are some of the materials for use with this process.

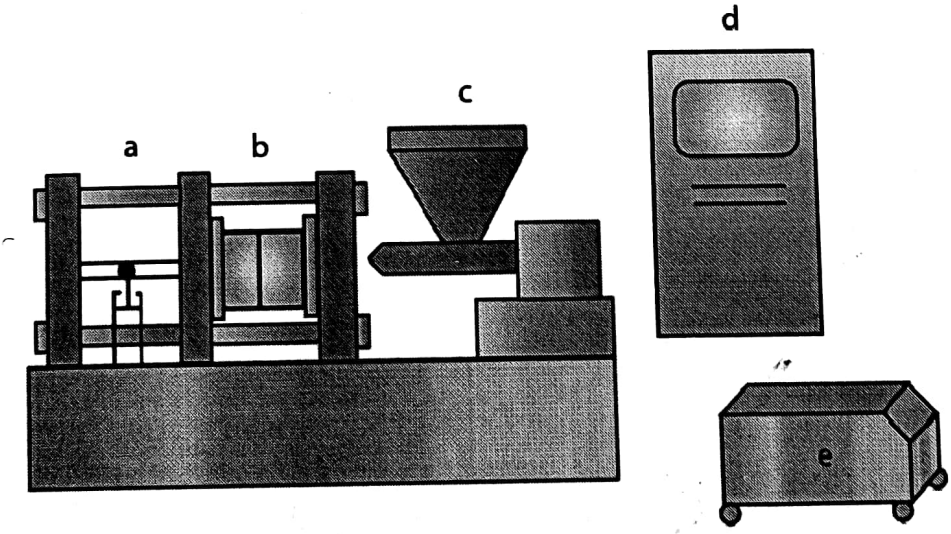


Blow Molding Process

5 . Injection Molding:

The Injection Molding technique is significant because of its ability to manufacture complex molding geometries in a single stage operation. The process is often suitable for mass production operations because of the high degree of automation. The Injection molding technique is a discontinuous process . The plastic pellets or granules are melted and injected under pressure into the moldcavity , wherein it is thermally cross-linked or solidified by cooling.

Through a runner system the hot melt prepared in the injection cylinder is injected into the cavity of the mold. The pressure is increased towards the end of the filling stage because of the increasing length of the flow path. After the injection phase, the holding pressure stage follows. It reduces the volume losses due to cooling of the melt , and thus, avoids marks and voids in the molding. After this , the molding is cooled sufficiently so that it is dimensionally stable for ejection. When the holding pressure phase is finished, the plastic is prepared for the next cycle by the plastication unit by rotating the screw. The melt is transported to the area in the front of the screw by the helical backward movement of the screw in the plastication cylinder against a back pressure. After this the molding is cooled and is mechanically removed from the mold via a handling equipment. The entire process is fully automated and is coordinated by a control unit.



Injection Molding Machine
a) Clamping unit; b) Mold; c)Plastication Unit; d) Control Unit; e)Temperature Control Unit